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STOLZ,J.F. Operating Reactors Branch 4

SUBJECT: Responds to 820405 request for addl info re pressurized thermal shock issue,including justification of time assumed for correct operator action in overcooling transient evaluations.Complete analysis by 820115.

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TITLE: Thermal Shock to Reactor Vessel

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April 30, 1982



Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. J. F. Stolz, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station, Unit 1
Docket No. 50-269

Dear Sir:

In response to your letter of April 5, 1982 concerning the pressurized thermal shock issue, please find attached our response to your request for additional information.

Although the predicted transient responses are being provided for delayed operator actions, Duke continues to maintain that the operator action time assumed in the previously provided analyses remains valid. Such analyses were conducted consistent with previous Staff guidance provided in the March 31, 1981 meeting with industry--that is, to provide best estimates of transients, not compounded by conservatisms to produce unrealistic worst-case transients. Duke considers that the assumption of time for operator action should be consistent with the severity of the postulated transient and the complexity of the required actions. As such, transient responses resulting from arbitrary assumptions in the timing of relevant and expected operator actions do not provide realistic estimation of expected plant response.

As in the case of many other severe accidents, reactor vessel thermal shock cannot be envisioned to be forgiving to all bounding and overly conservative assumptions. In order to obtain meaningful conclusions of the severity of the problem, it is necessary to systematically analyze accident conditions by considering relevant initiating events, mechanistic system failures, and credible operator actions, and by utilizing phenomenological models and methods that take into account realistic system boundary conditions and plant performance constraints. Such an analysis was provided by Duke on January 15, 1982.

Very truly yours,

William O. Parker, Jr.

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Attachments

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

Mr. W. T. Orders
NRC Resident Inspector
Oconee Nuclear Station

Response to Request for
Additional Information Concerning
Pressurized Thermal Shock

Concern

1. Provide an analysis or basis to justify the time assumed for correct operator action in the Overcooling Transient Evaluations, and in the Steam Line Break Evaluations.

Response

The operator actions assumed in the overcooling evaluations provided in the 150-day response to the August 21, 1981 request by the NRC were those related to terminating the excessive rate of heat removal from the reactor coolant system (RCS) following steam system failures, including main steam line ruptures and stuck-open turbine bypass valves. The actions credited and the time frames in which they were assumed to be taken were selected based on reasonable, realistic evaluations of operator response, as recommended by the NRC. All the actions are called for by emergency operating procedures and represent conventional, logical responses to the events of interest to regain stable RCS conditions; it should be emphasized that they are not novel actions instituted as a result of pressurized thermal shock or other recent concerns, nor are they inconsistent with operator priorities in maintaining core heat removal.

In order to optimize the time and expense involved in performing numerous detailed thermal-hydraulic and fracture mechanics analyses, a limited number of cases were analyzed, necessitating the predetermination of operator response times as inputs. The times chosen were judged to be well in excess of the actual time needed for diagnosis of the events and appropriate response, yet timely with respect to minimizing pressurized thermal shock. The specific operator actions assumed and the bases for those assumptions are outlined below:

Cases 9 & 10: Both cases involve failure of the TB valves on both steam generators to reclose following a reactor trip from full power. The ICS fails to runback main feedwater (MFW), resulting in continued full flow until the MFW pumps trip on high steam generator level. The tripping of the MFW pumps results in actuation of emergency feedwater (EFW), which responds and is controlled as designed. In Case 9, the reactor coolant pumps (RCPs) are assumed to remain in operation, while in Case 10 they are assumed to be tripped upon low RCS pressure actuation of the engineered safety features system (ESFS). In both cases it is assumed that operator action is taken to isolate EFW flow at 20 minutes, and for Case 10 it is also assumed that the TB valves are isolated at the same time.

The indications of such an event are clear and unambiguous, and include rapid decreases in RCS pressure and temperature, pressurizer level, and electrical load. Perhaps most significant is the rapid decrease in steam generator pressure, as indicated by a large gage centrally located in the control room;

this gage is closely monitored following a reactor trip in light of the information it provides relating to the status of heat removal from the RCS. Thus, diagnosis is straightforward, and the operators would likely begin taking corrective action within two to three minutes. The required actions, isolation of feedwater and closure of the turbine bypass valves, are specifically included as immediate actions in emergency procedure EP/0/A/1800/8, Steam Supply System Rupture. A significant portion of operator training is devoted to understanding and using emergency procedures, and immediate actions are required to be committed to memory. Therefore, 20 minutes is substantially more than adequate time for proper operator response, enhancing operator reliability.

A subjective evaluation of the operator reliability in taking the proper actions was performed within the context of the Oconee Probabilistic Risk Assessment Human Reliability Analysis, and the results were provided in the 150-day response. The factors identified in the preceding paragraph were weighed against considerations such as the attendant level of stress and the potential for confusing this event with another that would indicate similar behavior in some respects, such as a small-break loss-of-coolant accident. The operators were assessed to be quite reliable under these circumstances, and a fairly low probability of failure for isolating feedwater of $1 \times 10^{-2}$ was selected. Because of strong coupling between failure to isolate feedwater and failure to assure closure of the TB valves, a high probability of 0.3 was assigned to failure of one of these actions given that the other had not been taken properly.

Cases 11 & 12: Both cases include rupture of a main steam line, with operator action to isolated feedwater to the affected steam generator at 5 minutes. Two cases were run to investigate the effects of RCP operation: in Case 11 the RCPs were permitted to continue operating, while in Case 12 the RCPs were tripped upon low RCS pressure actuation of the ESFS.

The operator actions required are the same as those described for Cases 9 and 10, except that it is expected that the size of the break dictates that operator action be taken more promptly to avoid the potential for pressurized thermal shock. This quicker action is justified based on the fact that the steam generator depressurization would occur even more rapidly, providing for easier and more rapid recognition of the problem. Again, it should be noted that even for the more slowly evolving scenarios in Cases 9 and 10, correct action would be likely within 5 minutes. It should also be noted that operators faced with main steam line rupture events during simulator training have consistently taken the proper action within about 30 seconds, providing additional assurance. The reliability of the operators is further enhanced by the fact that they are not required to make a determination of which steam line is broken; the procedure instructs them to isolate both steam generators, only then making that determination and restoring feedwater to the intact generator. The portion of the emergency procedure listing subsequent actions includes instructions to start two of the RCPs when 50°F subcooling is regained. Because subcooling margin would be monitored quite closely under these conditions, and because the operators prefer RCP operation to natural circulation cooling, this action is also considered to be reliable.

Quantitative estimates of operator reliability were provided for these cases as well. In view of the much shorter time available for action, the probability of failure to isolate feedwater was assessed to be somewhat higher than for the TB valve cases, and was estimated to be $5 \times 10^{-2}$. The likelihood of failure either to isolate feedwater or to restart the RCPs for Case 12 was assessed to be 0.1. Again, these values indicate that reliance on operator action is justified and acceptable.

Case 13: This case involves a main steam line rupture, and differs from Case 12 in that the ICS fails to runback MFW, resulting in a high level trip of the MFW pumps and actuation of EFW. Operator response would be virtually identical to that described for the preceding cases.

Concern

2. In the cases for the overcooling transients and steam line break analyses, provide an evaluation of the sensitivity of the transients to the time assumed for operator action (i.e., if the operator isolates the feedwater 5, 10 or 20 minutes later than assumed or restarts an RCP 10 or 20 minutes later than assumed, what are the resulting pressure/temperature transients?).

Response

The sensitivity of the overcooling transient pressure/temperature responses to the time assumed for operator action is addressed utilizing the results of three additional RETRAN simulations, along with interpretations of the results presented in DPC-RS-1001.

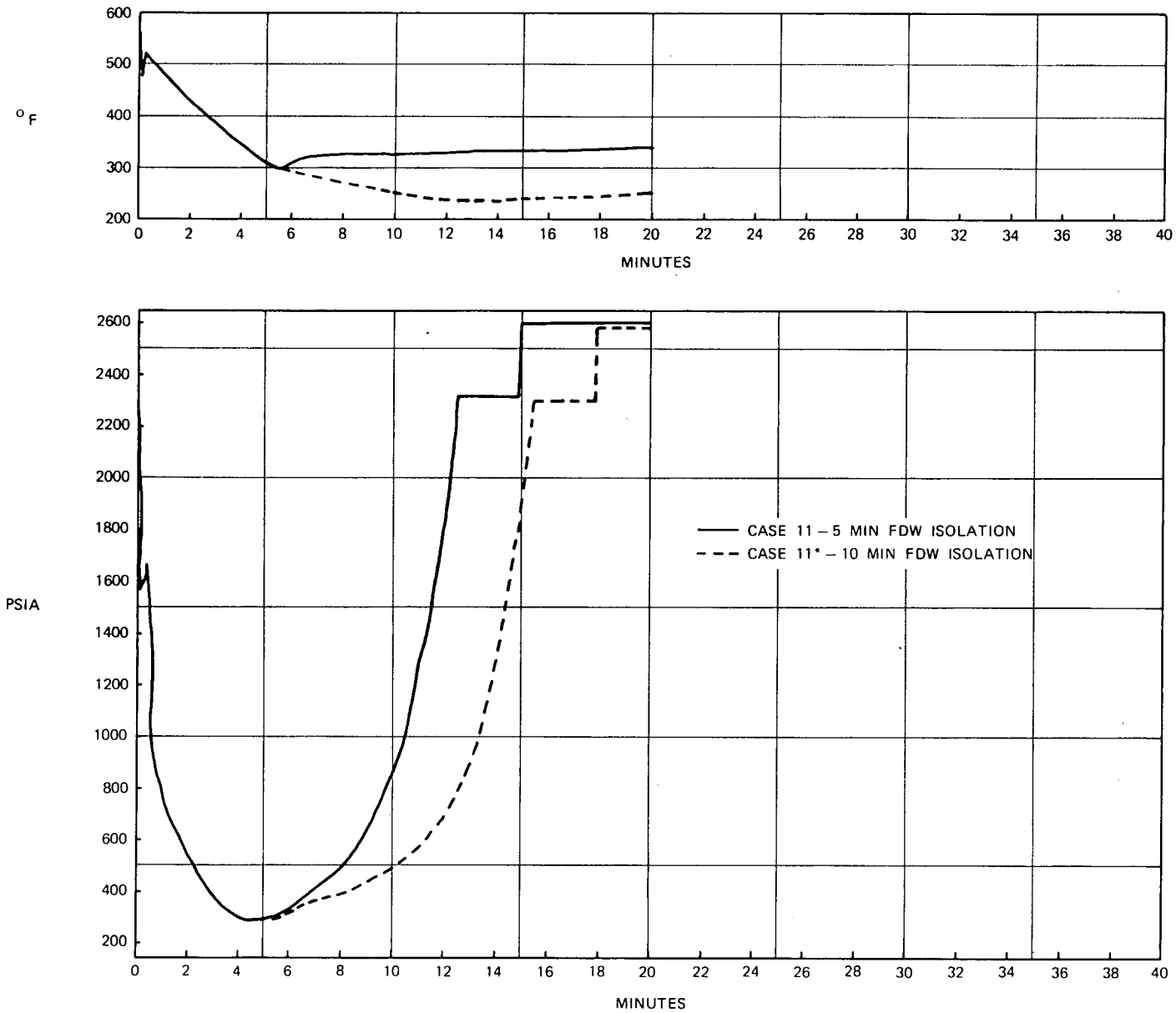
For the steam generator overfeed transients and the turbine bypass failure initiated transients (Cases 1-10), operator action to isolate feedwater and the turbine bypass valves was assumed 20 minutes after transient initiation. Restart of the reactor coolant pumps was not considered. The results of the analyses show that for each case the trend of the cooldown/repressurization is very well established by 20 minutes. Operator action only serves to limit the established asymptotic trend. The sensitivity to a delay in the assumed operator action can be approximated by an extrapolation of the trend. No additional simulations were performed on Cases 1-10 on this basis.

For the steam line break transients (Cases 11-13), the operator was assumed to isolate feedwater at 5 minutes and restart the reactor coolant pumps at 10 minutes. Since Case 13 was shown to be bounded by Case 12, the evaluation of the sensitivity of the time assumed for operator action was limited to Cases 11 and 12. The results of Cases 11 and 12 showed that the assumed operator action had an effective and prompt mitigative impact on the system cooldown response. An extrapolation of the system response was not appropriate since the trends were not established. In order to determine the effect of an additional delay in operator action, three sensitivity simulations were selected with the intent of addressing the NRC staff's concerns.

The first sensitivity simulation involves increasing the time assumed for feedwater isolation for Case 11 from 5 minutes to 10 minutes. The results of this simulation are shown in Figure 1.

The second sensitivity simulation involves increasing the time assumed for reactor coolant pump restart for Case 12 from 10 minutes to 15 minutes. The results of this simulation are shown in Figure 2.

The third sensitivity simulation involves increasing the time assumed for feedwater isolation for Case 12 from 5 minutes to 10 minutes, and also considers restart of the reactor coolant pumps at 10 and 15 minutes. This analysis assumes the reactor vessel internals vent valves function as designed. The original Case 12 scenario assumed that the vent valves did not function. This assumption has been rejected as unrealistic, such that sensitivities on that case are not appropriate. The results of this simulation are shown in Figure 3.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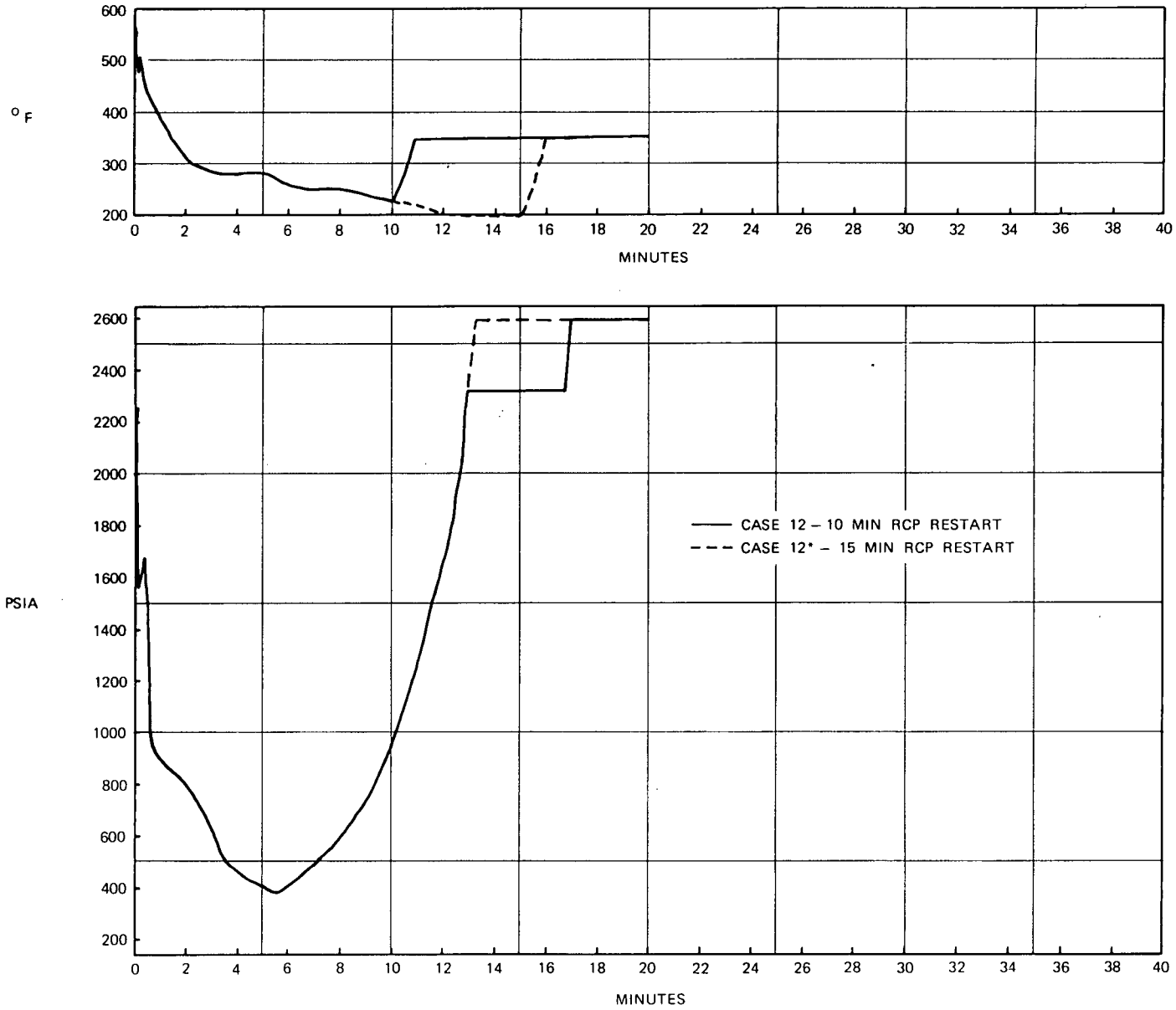
CASE 11 – 5 MIN FDW ISOLATION
CASE 11* – 10 MIN FDW ISOLATION
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
MINUTES

Figure 1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CASE 12 – 10 MIN RCP RESTART
CASE 12* – 15 MIN RCP RESTART
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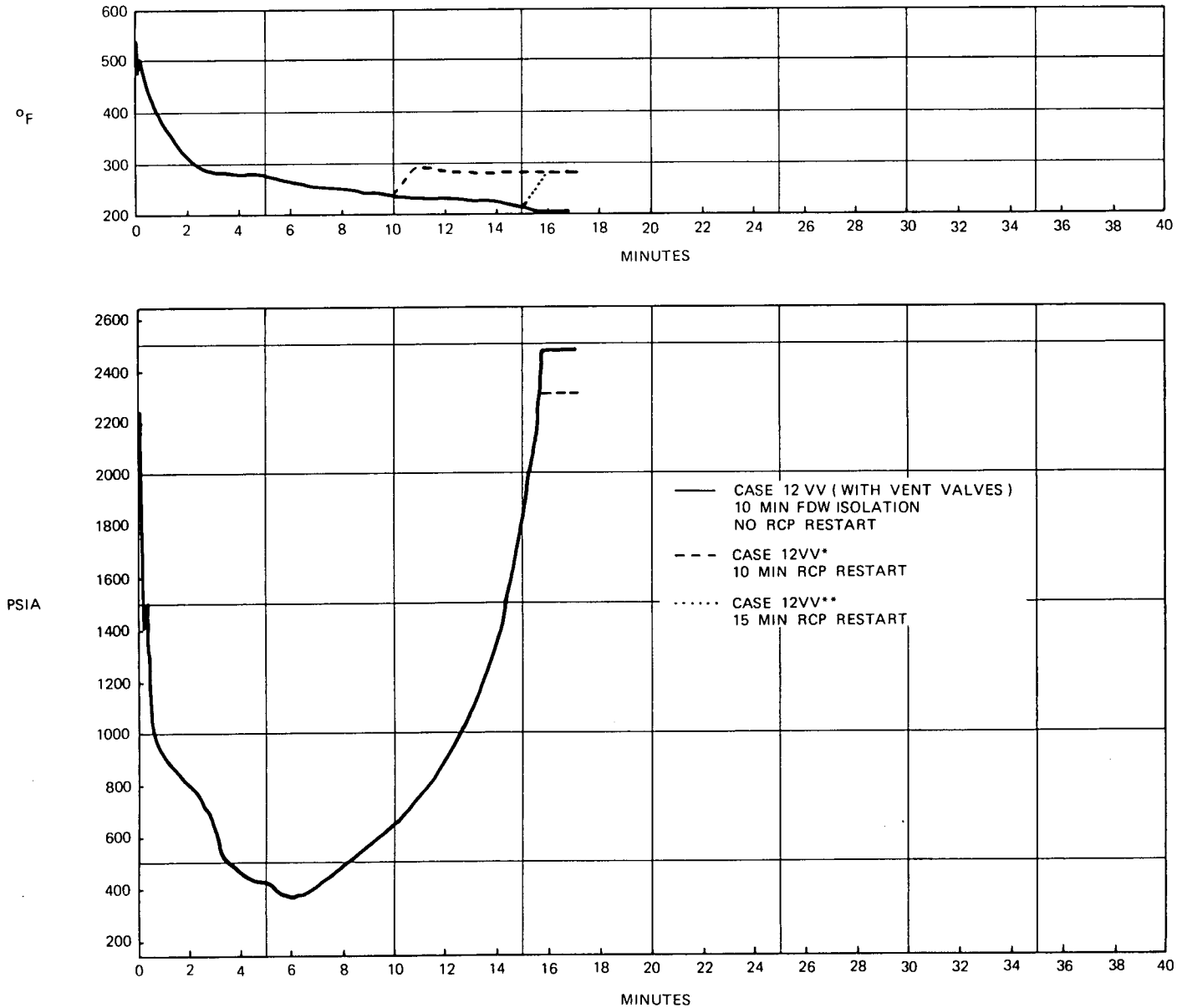
Figure 2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0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
MINUTES
CASE 12 VV ( WITH VENT VALVES )
10 MIN FDW ISOLATION
NO RCP RESTART
CASE 12VV*
10 MIN RCP RESTART
CASE 12VV**
15 MIN RCP RESTART

Figure 3